

1 CLAIMS:

2 1. A low k interlevel dielectric layer fabrication method  
3 comprising:

4 providing a substrate having integrated circuitry at least partially  
5 formed thereon;

6 forming an oxide comprising interlevel dielectric layer comprising  
7 carbon and having a dielectric constant no greater than 3.5 over said  
8 substrate; and

9 after forming the carbon comprising dielectric layer, exposing it to  
10 a plasma comprising oxygen effective to reduce the dielectric constant  
11 to below what it was prior to said exposing.

12  
13 2. The method of claim 1 wherein the exposing is effective to  
14 increase stability of the dielectric constant to variation from what it was  
15 prior to the exposing.

16  
17 3. The method of claim 1 comprising exposing the carbon  
18 comprising dielectric layer to a plasma comprising oxygen effective to  
19 reduce the dielectric constant to at least 15% below what it was prior  
20 to said exposing.

21  
22 4. The method of claim 1 wherein the oxygen comprising  
23 plasma is at least in part derived from O<sub>2</sub>.  
24

1           5.    The method of claim 1 wherein the oxygen comprising  
2 plasma is at least in part derived from  $O_3$ .

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4           6.    The method of claim 1 wherein the oxygen comprising  
5 plasma is at least in part derived from  $N_2O$ .

6  
7           7.    The method of claim 1 wherein the oxygen comprising  
8 plasma is at least in part derived from  $NO_x$ .

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10          8.    The method of claim 1 wherein the dielectric layer  
11 comprising carbon is formed by chemical vapor deposition in a chamber,  
12 the exposing occurring within the chamber without removing the  
13 substrate from the chamber between the forming and the exposing.

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15          9.    The method of claim 8 wherein the chemical vapor  
16 deposition is plasma enhanced.

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18          10.   The method of claim 1 wherein the temperature during the  
19 exposing is always less than or equal to  $550^{\circ}C$ .

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21          11.   The method of claim 1 wherein the plasma exposing is  
22 ineffective to appreciably etch the interlevel dielectric layer.

12. The method of claim 1 wherein the dielectric layer subjected to the exposing comprises silicon bonded to organic material.

13. The method of claim 1 wherein the dielectric layer subjected to the exposing comprises silicon atoms bonded to both organic material and nitrogen.

14. The method of claim 1 wherein the carbon is present as a  $\text{CH}_3$  group.

15. The method of claim 1 wherein the dielectric layer subjected to the exposing comprises  $(\text{CH}_3)_x\text{SiO}_y$ .

16. The method of claim 1 wherein the dielectric layer subjected to the exposing comprises  $(\text{CH}_3)_x\text{SiO}_y$  which remains as  $(\text{CH}_3)_x\text{SiO}_y$  after the exposing.

17. The method of claim 1 wherein the dielectric layer subjected to the exposing consists essentially of  $(\text{CH}_3)_x\text{SiO}_y$ .

18. The method of claim 1 wherein the dielectric layer subjected to the exposing comprises  $(\text{CH}_3)_x\text{SiO}_y$  which remains as  $(\text{CH}_3)_x\text{SiO}_y$  after the exposing, and wherein the exposing comprises at least 20 seconds.

19. The method of claim 1 wherein a whole of the dielectric layer subjected to the exposing is not transformed from one base chemistry to another by the exposing.

20. The method of claim 1 wherein the dielectric layer subjected to the exposing comprises silicon bonded to organic material, a whole of the dielectric layer subjected to the exposing is not transformed from one base chemistry to another by the exposing, and the exposing comprises at least 20 seconds.

21. The method of claim 1 wherein the dielectric layer subjected to the exposing comprises silicon bonded to organic material, a whole of the dielectric layer subjected to the exposing is not transformed from one base chemistry to another by the exposing, and the exposing comprises at least 40 seconds.

1 22. The method of claim 1 wherein the dielectric layer subjected  
2 to the exposing comprises silicon bonded to organic material, a whole  
3 of the dielectric layer subjected to the exposing is not transformed from  
4 one base chemistry to another by the exposing, and the exposing  
5 comprises at least 60 seconds.

6  
7 23. The method of claim 1 wherein the dielectric layer subjected  
8 to the exposing comprises silicon bonded to organic material, a whole  
9 of the dielectric layer subjected to the exposing is not transformed from  
10 one base chemistry to another by the exposing, and the exposing  
11 comprises at least 80 seconds. X

12  
13 24. The method of claim 1 wherein the dielectric layer subjected  
14 to the exposing comprises silicon bonded to organic material, a whole  
15 of the dielectric layer subjected to the exposing is not transformed from  
16 one base chemistry to another by the exposing, and the exposing  
17 comprises at least 100 seconds.

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19 25. The method of claim 1 wherein the majority of the carbon  
20 present in the dielectric layer is in the form of methyl groups, and  
21 wherein the methyl groups comprise from 10% to about 50% of the  
22 dielectric layer (mole percent) before and after the exposing.  
23  
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1 ~~1~~ 26. A low k interlevel dielectric layer fabrication method  
2 comprising:

3 providing a substrate having integrated circuitry at least partially  
4 formed thereon;

5 forming a nitride comprising interlevel dielectric layer comprising  
6 carbon and having a dielectric constant no greater than 8.0 over said  
7 substrate; and

8 after forming the carbon comprising dielectric layer, exposing it to  
9 a plasma comprising nitrogen effective to reduce the dielectric constant  
10 to below what it was prior to said exposing.

11 ~~2~~ 27. The method of claim ~~26~~ wherein the nitrogen comprising  
12 plasma is at least in part derived from  $N_2$ .

13 ~~3~~ 28. The method of claim ~~26~~ wherein the nitrogen comprising  
14 plasma is at least in part derived from  $NH_3$ .

15 ~~4~~ 29. The method of claim ~~26~~ wherein the nitrogen comprising  
16 plasma is at least in part derived from  $N_2H_4$ .

17 ~~5~~ 30. The method of claim ~~26~~ wherein the nitrogen comprising  
18 plasma is at least in part derived from  $N_2O$ .

1 ~~6~~ 31. The method of claim ~~26~~<sup>1</sup> wherein the nitrogen comprising  
2 plasma is at least in part derived from NO<sub>x</sub>.

3  
4 ~~7~~ 32. The method of claim ~~26~~<sup>1</sup> wherein the dielectric layer  
5 comprising carbon is formed by chemical vapor deposition in a chamber,  
6 the exposing occurring within the chamber without removing the  
7 substrate from the chamber between the forming and the exposing.

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9 ~~8~~ 33. The method of claim ~~26~~<sup>1</sup> wherein the carbon is present as  
10 a CH<sub>3</sub> group.  
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1 34. A low k interlevel dielectric layer fabrication method  
2 comprising:

3 providing a substrate having integrated circuitry at least partially  
4 formed thereon;

5 in a chamber, plasma enhanced chemical vapor depositing an  
6 interlevel dielectric layer comprising carbon and having a dielectric  
7 constant no greater than 3.5 over said substrate at subatmospheric  
8 pressure; and

9 after forming the carbon comprising dielectric layer, exposing it to  
10 a plasma comprising oxygen at a subatmospheric pressure effective to  
11 reduce the dielectric constant by at least 10% below what it was prior  
12 to said exposing, the exposing occurring without removing the substrate  
13 from the chamber between the depositing and the exposing, and  
14 pressure within the chamber being maintained at subatmospheric between  
15 the depositing and the exposing.  
16

17 35. The method of claim 34 wherein at least two precursors are  
18 fed to the chamber during the depositing, one of the precursors  
19 comprising oxygen, the exposing comprising substantially ceasing feeding  
20 another of the precursors while feeding the one, and maintaining plasma  
21 conditions within the chamber from the depositing through the exposing.  
22  
23  
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1 36. The method of claim 34 wherein the plasma enhanced  
2 chemical vapor depositing comprises feeding a methyl silane to the  
3 chamber.

4  
5 37. The method of claim 34 wherein the dielectric layer  
6 comprises silicon bonded to organic material.

7  
8 38. The method of claim 34 wherein the dielectric layer  
9 comprises silicon atoms bonded to both organic material and nitrogen.  
10

11 39. The method of claim 34 wherein the oxygen comprising  
12 plasma is at least in part derived from  $O_2$ .

13  
14 40. The method of claim 34 wherein the oxygen comprising  
15 plasma is at least in part derived from  $O_3$ .

16  
17 41. The method of claim 34 wherein the oxygen comprising  
18 plasma is at least in part derived from  $N_2O$ .

19  
20 42. The method of claim 34 wherein the oxygen comprising  
21 plasma is at least in part derived from  $NO_x$ .  
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1 43. The method of claim 34 wherein the dielectric layer  
2 subjected to the exposing comprises  $(\text{CH}_3)_x\text{SiO}_y$ .

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4 44. The method of claim 34 wherein the dielectric layer  
5 subjected to the exposing comprises  $(\text{CH}_3)_x\text{SiO}_y$  which remains as  
6  $(\text{CH}_3)_x\text{SiO}_y$  after the exposing.

7  
8 45. The method of claim 34 wherein the dielectric layer  
9 subjected to the exposing consists essentially of  $(\text{CH}_3)_x\text{SiO}_y$ .

10  
11 46. The method of claim 34 wherein the dielectric layer  
12 subjected to the exposing comprises  $(\text{CH}_3)_x\text{SiO}_y$  which remains as  
13  $(\text{CH}_3)_x\text{SiO}_y$  after the exposing, and wherein the exposing comprises at  
14 least 20 seconds.

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16 47. The method of claim 34 wherein a whole of the dielectric  
17 layer subjected to the exposing is not transformed from one base  
18 chemistry to another by the exposing.

1 48. The method of claim 34 wherein the dielectric layer  
2 subjected to the exposing comprises silicon bonded to organic material,  
3 a whole of the dielectric layer subjected to the exposing is not  
4 transformed from one base chemistry to another by the exposing, and  
5 the exposing comprises at least 20 seconds.

6  
7 49. The method of claim 34 wherein the dielectric layer  
8 subjected to the exposing comprises silicon bonded to organic material,  
9 a whole of the dielectric layer subjected to the exposing is not  
10 transformed from one base chemistry to another by the exposing, and  
11 the exposing comprises at least 40 seconds.

12  
13 50. The method of claim 34 wherein the dielectric layer  
14 subjected to the exposing comprises silicon bonded to organic material,  
15 a whole of the dielectric layer subjected to the exposing is not  
16 transformed from one base chemistry to another by the exposing, and  
17 the exposing comprises at least 60 seconds.

18  
19 51. The method of claim 34 wherein the majority of the carbon  
20 present in the dielectric layer is in the form of methyl groups, and  
21 wherein the methyl groups comprise from 10% to about 50% of the  
22 dielectric layer (mole percent) before and after the exposing.  
23  
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1 ~~52~~ A low k interlevel dielectric layer fabrication method  
2 comprising:

3 providing a substrate having integrated circuitry at least partially  
4 formed thereon;

5 forming an interlevel dielectric layer comprising a compound having  
6 silicon bonded to both nitrogen and an organic material and having a  
7 dielectric constant no greater than 8.0 over said substrate; and

8 after forming the dielectric layer, exposing it to a plasma  
9 comprising nitrogen effective to reduce the dielectric constant to below  
10 what it was prior to said exposing.

11 ~~20~~ ~~53~~ The method of claim ~~52~~ comprising exposing the dielectric  
12 layer to a plasma comprising nitrogen effective to reduce the dielectric  
13 constant to at least 15% below what it was prior to said exposing.

14 ~~3~~ ~~54~~ The method of claim ~~52~~ wherein the nitrogen comprising  
15 plasma is at least in part derived from N<sub>2</sub>.

16 ~~4~~ ~~55~~ The method of claim ~~52~~ wherein the nitrogen comprising  
17 plasma is at least in part derived from NH<sub>3</sub>.

18 ~~10~~ ~~56~~ The method of claim ~~52~~ wherein the nitrogen comprising  
19 plasma is at least in part derived from N<sub>2</sub>H<sub>4</sub>.

6 14  
57. The method of claim 52 wherein the nitrogen comprising  
plasma is at least in part derived from  $N_2O$ .

7 15  
58. The method of claim 52 wherein the nitrogen comprising  
plasma is at least in part derived from  $NO_x$ .

8 16  
59. The method of claim 52 wherein the exposing is void of  
oxygen.

9 17  
60. The method of claim 52 wherein the dielectric layer is  
formed by chemical vapor deposition in a chamber, the exposing  
occurring within the chamber without removing the substrate from the  
chamber between the forming and the exposing.

10 18  
61. The method of claim 52 wherein the plasma exposing is  
ineffective to appreciably etch the interlevel dielectric layer.

11 19  
62. The method of claim 52 wherein a whole of the dielectric  
layer subjected to the exposing is not transformed from one base  
chemistry to another by the exposing.

~~64~~. The method of claim ~~52~~ wherein the dielectric layer subjected to the exposing consists essentially of  $(\text{CH}_3)_x\text{Si}_3\text{N}_{(4-x)}$ , with x being greater than 0 and no greater than 4.